

WHAT IS CLAIMED IS:

1. A braking system comprising:

a master cylinder including a housing, and at least two pressurizing pistons which are fluid-tightly and slidably fitted in said housing and which cooperate with said housing to define at least two pressurizing chambers which are isolated from each other, and wherein a working fluid in each of said at least two pressurizing chambers is pressurized by an advancing movement of a corresponding one of said at least two pressurizing pistons;

a hydraulically operable brake cylinder for activating a brake; and

a valve device having a first state in which the pressurized fluid is delivered from two pressurizing chambers of said at least two pressurizing chambers to said brake cylinder, and a second state in which the pressurized fluid is delivered from only one of said two pressurizing chambers.

2. A braking system according to claim 1, wherein said valve device is placed in said first state while the pressure of the pressurized fluid in one of said two pressurizing chambers is not higher than a predetermined value, and is placed in said second state while the pressure of the pressurized fluid in said one pressurizing chamber is higher than said predetermined value, said valve device placed in said second state inhibiting a flow of the pressurized fluid from said one pressurizing chamber to said brake cylinder, and permitting a flow of the pressurized

fluid from the other of said two pressurizing chambers to said brake cylinder.

3. A braking system according to claim 1, wherein said valve device is placed in said first state while the pressure of the pressurized fluid in one of said two pressurizing chambers is higher than that in the other of said two pressurizing chambers, and is placed in said second state while the pressure of the pressurizing fluid in said one pressurizing chamber is not higher than that in said other pressurizing chamber, said valve device placed in said second state permitting a flow of the pressurized fluid from said other pressurizing chamber to said brake cylinder and inhibiting a flow of the pressurized fluid from said one pressurizing chamber to said brake cylinder.

4. A braking system according to claim 1, wherein said brake cylinder is connected to a first pressurizing chamber which is one of said two pressurizing chambers, and said valve device includes an internal valve incorporated within said master cylinder, said valve device having a state in which the pressurized fluid supplied from a second pressurizing chamber which is the other of said two pressurizing chambers, to said first pressurizing chamber, and a state in which the pressurized fluid is not supplied from said second pressurizing chamber to said first pressurizing chamber.

5. A braking system according to claim 4, wherein said internal valve is a check valve which permits a flow of the pressurized fluid in a first direction from said second pressurizing chamber toward said first pressurizing chamber and inhibits a flow of the pressurized fluid in a second direction opposite to said first direction.

6. A braking system according to claim 4, further comprising a low-pressure source, and wherein said valve device further includes a pressure relief valve which inhibits a discharge flow of the pressurized fluid from said second pressurizing chamber into said low-pressure source when the pressure of the pressurized fluid in said second pressurizing chamber is not higher than a predetermined value, and permits said discharge flow when the pressure of the pressurized fluid in said second pressurizing chamber is higher than said predetermined value.

7. A braking system according to claim 1, further comprising two separate fluid passages which are connected to said two pressurizing chambers, respectively, and which merge into a common fluid passage to which said brake cylinder is connected, said valve device including at least one valve provided in at least one of said two separate fluid passages.

8. A braking system according to claim 7, wherein said at least one valve of said valve device includes at

least one switch valve which is provided in at least one of said two separate fluid passages and which is operable between two states for respectively permitting and inhibiting a flow of the fluid from the corresponding pressurizing chamber toward said brake cylinder.

9. A braking system according to claim 7, further comprising a low-pressure source, and wherein said at least one valve of said valve device includes a pressure relief valve connected to one of said two separate fluid passages, said pressure relief valve inhibiting a discharge flow of the pressurized fluid from the corresponding one of said two pressurizing chamber to said low-pressure source while the pressure of the pressurized fluid in said corresponding pressurizing chamber is not higher than a predetermined value, and permitting said discharge flow of the pressurized fluid while the pressure of the pressurized fluid in said corresponding pressurizing chamber is higher than said predetermined value.

10. A braking system according to claim 9, wherein said at least one valve of said valve device further includes a check valve provided in said one of said two separate fluid passages, said check valve permitting a flow of the pressurized fluid in a first direction from said corresponding pressurizing chamber toward said brake cylinder and inhibiting a flow of the pressurized fluid in a second direction opposite to said first direction.

11. A braking system according to claim 1, further comprising a stroke simulating device including a stroke simulator connected to one of said at least two pressurizing chambers, and a simulator control valve operable to control said stroke simulator.

12. A braking system according to claim 11, wherein said stroke simulator permits a flow of the pressurized fluid from said corresponding pressurizing chamber into said stroke simulator while the pressure of the pressurized fluid in said corresponding pressurizing chamber is higher than a predetermined value.

13. A braking system according to claim 1, wherein said valve device includes a master-cylinder cut-off valve disposed between at least one of said at least two pressurizing chambers and said brake cylinder, said master-cylinder cut-off valve having an open state in which said brake cylinder is communicated with said at least one of said at least two pressurizing chambers, and a closed state in which said brake cylinder is isolated from said at least one of said at least two pressurizing chambers.

14. A braking system according to claim 13, further comprising two separate fluid passages which are connected to said two pressurizing chambers, respectively, and

wherein said master-cylinder cut-off valve is disposed in each of at least one of said two separate fluid passages, and said valve device further includes a first check valve which is disposed in parallel connection with said master-cylinder cut-off valve and which permits a flow of the pressurized fluid in a first direction from a corresponding one of said two pressurizing chambers toward said brake cylinder and inhibits a flow of the pressurized fluid in a second direction opposite to said first direction.

15. A braking system according to claim 14, wherein said master-cylinder cut-off valve is disposed in one of said two separate fluid passages which is connected to one of said two pressurizing chambers, and said valve device includes a pressure relief valve and a second check valve which are connected to the other of said two pressurizing chambers, said pressure relief valve being switched from a closed state to an open state when the pressure of the pressurized fluid in said other pressurizing chamber becomes higher than a predetermined value, said second check valve permitting a flow of the pressurizing fluid in a first direction from said other pressurizing chamber toward said brake cylinder and inhibits a flow of the pressurized fluid in a second direction opposite to said first direction.

16. A braking system according to claim 1, wherein said housing has a large-diameter portion and a small-diameter portion which is located in front of said

large-diameter portion and which has a smaller diameter than said large-diameter portion, and one of said at least one pressurizing pistons is a large-diameter piston fluid-tightly and slidably fitted in said large-diameter portion, while another of said at least two pressurizing pistons is a small-diameter piston fluid-tightly and slidably fitted in said small-diameter portion, said large-diameter and small-diameter pistons being moved as a unit, said small-diameter piston partially defining one of said two pressurizing chambers in front of said small-diameter portion, while said large-diameter piston and said small-diameter piston partially defining therebetween the other of said two pressurizing chambers.

17. A braking system according to claim 16, wherein said valve device includes a pressure relief valve and an orifice which are connected to one of said two pressurizing chambers such that said pressure relief valve and said orifice are disposed in parallel with each other.

18. A braking system according to claim 1, wherein said at least two pressurizing pistons include two pressurizing pistons have respective different pressure-receiving surface areas which partially define said two pressurizing chambers, respectively.

19. A braking system according to claim 1, wherein said two pressurizing chambers of said master cylinder

have different transverse cross sectional areas.

20. A braking system according to claim 1, wherein said master cylinder is a master cylinder of tandem type includes two pressurizing pistons arranged in series with each other and partially defining a front and a rear pressurizing chamber, respectively, said front pressurizing chamber being connected to a first brake cylinder while said rear pressurizing chamber being connected to a second brake cylinder, said valve device including a directional control valve disposed between said first and second brake cylinders and one of said front and rear pressurizing chambers, said directional control valve having a first and a second state for fluid communication of said one pressurizing chamber and said first and second brake cylinders, respectively.

21. A braking system according to claim 1, wherein said master cylinder has a rear pressure chamber partially defined by a rear surface of one of said at least two pressurizing pistons, said braking system further comprising a master-cylinder pressure control device operable to control a pressure of the fluid in said rear pressure chamber of said master cylinder.

22. A braking system according to claim 1, further comprising an assisting pressure control device disposed



between said master cylinder and said brake cylinder and operable to control the pressure of the fluid in said brake cylinder such that the pressure of the fluid in said brake cylinder is higher than that of the fluid in said master cylinder.

23. A braking system according to claim 22, wherein said assisting pressure control device comprising (a) an assisting cylinder including a housing, and an assisting piston which is fluid-tightly and slidably fitted in said housing and which cooperates with said housing to define an assisting chamber connected to said brake cylinder, and (b) a power-operated assisting-piston drive device operable to move said assisting piston relative to said housing.

24. A braking system according to claim 22, further comprising a braking-pressure control valve device disposed between said assisting cylinder and said brake cylinder.

25. A braking system comprising:

a master cylinder including a housing, and a pressurizing piston which is fluid-tightly and slidably fitted in said housing and which is operatively connected to a manually operable brake operating member, said pressurizing piston cooperating with said housing to define a pressurizing chamber and a rear pressure chamber on respective front and rear sides thereof;

a brake cylinder connected to said pressurizing chamber;

an assisting cylinder including a housing, and an assisting

piston fluid-tightly and slidably fitted in said housing and cooperating with said housing to define an assisting chamber in front of said assisting piston, said assisting chamber being connected to said brake cylinder and said master cylinder such that said assisting chamber is located between said brake cylinder and said master cylinder;

a master-cylinder cut-off valve disposed between said assisting chamber and said pressurizing chamber, and having an open state in which said assisting chamber and said pressurizing chamber are communicated with each other, and a closed state in which said assisting chamber and said pressurizing chamber are isolated from each other;

a stroke simulating device operable to permit flows of a working fluid between said stroke simulating device and said pressurizing chamber according to a movement of said pressurizing piston while said master-cylinder cut-off valve is placed in said closed state, such that said stroke simulating device applies to said pressurizing piston a reaction force which corresponds to a pressure of the fluid in said pressurizing chamber; and

a braking characteristic control device operable to control at least one of a pressure of the fluid in said rear pressure chamber and the pressure of the fluid in said pressurizing chamber, for thereby controlling braking characteristics of the braking system,

and wherein said braking characteristic control device comprises:

a first control portion operable while said master-cylinder cut-off valve is placed in said closed state, to control the pressure of the fluid in said rear pressure chamber on the basis of an operating stroke of said brake operating member, and control the pressure of the fluid in said assisting chamber on the basis of an operating force of said brake operating member; and

a second control portion operable while said master-cylinder is placed in said open state, to control the pressure of the rear pressure chamber on the basis of said operating force, and control the pressure of the fluid in said assisting chamber on the basis of said operating stroke.

26. A braking system according to claim 25, which is adapted to be installed on a vehicle, wherein said braking characteristic control device further comprises a control-portion selecting portion operable to select one of said first and second control portions on the basis of an operating state of said vehicle.

27. A braking system according to claim 25, wherein said housing and said assisting piston of said assisting cylinder cooperate to define an assisting rear pressure chamber on a rear side of said assisting piston remote from said assisting chamber, said assisting cylinder being operated according to the pressure of the fluid in said assisting rear pressure chamber, said braking system further comprising a hydraulic pressure source operable to deliver a pressurized fluid used commonly for said

rear pressure chamber of said master cylinder and said assisting rear pressure chamber of said assisting cylinder,

and wherein said braking characteristic control device includes a distribution ratio control portion operable while said master-cylinder cut-off valve is placed in said closed state, to control a ratio of a rate of flow of the pressurized fluid from said hydraulic pressure source to said assisting rear pressure chamber of said assisting chamber, to a rate of flow of the pressurized fluid from said hydraulic pressure source to said rear pressure chamber of said master cylinder.

28. A braking system according to claim 27, wherein said ratio control portion includes a first cut-off valve disposed between said hydraulic pressure source and said rear pressure chamber of said master cylinder and having an open state and a closed state in which said rear pressure chamber is communicated with and isolated from said hydraulic pressure source, respectively, a second cut-off valve disposed between said hydraulic pressure source and said assisting rear pressure chamber and having an open state and a closed state in which said assisting rear pressure chamber is communicated with and isolated from said hydraulic pressure source, and a cut-off valve control portion operable to control at least one of said first and second cut-off valves for thereby controlling the rates of flows of the pressurized fluid from said hydraulic pressure source to said rear pressure chamber of said master cylinder and said assisting rear pressure chamber of said assisting cylinder.

29. A braking system comprising:

a master cylinder including a pressurizing piston which is operatively connected to a manually operable brake operating member and which defines a pressurizing chamber and a rear pressure chamber on respective front and rear sides thereof;

a brake cylinder connected to said pressurizing chamber;

an assisting cylinder including a housing, and an assisting piston fluid-tightly and slidably fitted in said housing and cooperating with said housing to define an assisting chamber and an assisting rear pressure chamber on respective front and rear sides thereof, said assisting chamber being connected to said brake cylinder and said master cylinder such that said assisting chamber is located between said brake cylinder and said master cylinder wherein said assisting cylinder being operated according to the pressure of the fluid in said assisting rear pressure chamber;

a master-cylinder cut-off valve disposed between said assisting chamber and said pressurizing chamber, and having an open state in which said assisting chamber and said pressurizing chambers are communicated with each other, and a closed state in which said assisting chamber and said pressurizing chamber are isolated from each other;

a braking characteristic control device operable to control at least one of a pressure of the fluid in said rear pressure chamber of said master cylinder and a pressure of the fluid said assisting rear pressure chamber, for thereby controlling braking characteristics of the braking system; and

a hydraulic pressure source operable to deliver a pressurized fluid used commonly for said rear pressure chamber of said master cylinder and said assisting rear pressure chamber of said assisting cylinder,

and wherein said braking characteristic control device includes a distribution ratio control portion operable while said master-cylinder cut-off valve is placed in said closed state, to control a ratio of a rate of flow of the pressurized fluid from said hydraulic pressure source to said assisting rear pressure chamber of said assisting chamber, to a rate of flow of the pressurized fluid from said hydraulic pressure source to said rear pressure chamber of said master cylinder.

30. A braking system according to claim 25, further comprising at least one of:

a first diagnosing device operable while said master-cylinder cut-off valve is in said closed state, to diagnose a manual-pressure-generating system on the basis of a relationship between an operating state of said manually operable brake operating member and the pressure of the fluid in said pressurizing chamber of said master cylinder; and

a second diagnosing device operable while said master-cylinder cut-off valve is in said closed state, to diagnose a brake-cylinder activating system on the basis of a relationship between the pressure of the fluid in said brake cylinder and an operating state of said assisting cylinder.

31. A braking system according to claim 29, further comprising at least one of:

a first diagnosing portion operable while said master-cylinder cut-off valve is in said closed state, to diagnose a manual-pressure-generating system on the basis of a relationship between an operating state of said manually operable brake operating member and the pressure of the fluid in said pressurizing chamber of said master cylinder; and

a second diagnosing portion operable while said master-cylinder cut-off valve is in said closed state, to diagnose a brake-cylinder activating system on the basis of a relationship between the pressure of the fluid in said brake cylinder and an operating state of said assisting cylinder.

32. A braking system according to claim 25, further comprising a third diagnosing device operable to diagnose the braking system, on the basis of at least two relationships selected from relationships between at least two of the operating state of said brake operating member, the fluid pressure in said pressurizing chamber of said master cylinder, the operating state of said assisting cylinder, and the fluid pressure in said brake cylinder, which are obtained while said master-cylinder cut-off valve is in at least one of said closed and open states.

33. A braking system according to claim 29, further comprising a third diagnosing device operable to diagnose the braking system, on the basis of at least two relationships

selected from relationships between at least two of the operating state of said brake operating member, the fluid pressure in said pressurizing chamber of said master cylinder, the operating state of said assisting cylinder, and the fluid pressure in said brake cylinder, which are obtained while said master-cylinder cut-off valve is in said closed and open states.

34. A braking system according to claim 30, wherein said control-portion selecting portion is operable to select said first control portion when said first diagnosing device has detected that said manual-pressure-generating system is defective.

35. A braking system according to claim 32, wherein said control-portion selecting portion is operable to select said first control portion when said first diagnosing device has detected that said manual-pressure-generating system is defective.

36. A braking system comprising:

- a master cylinder including a pressurizing piston which is operatively connected to a manually operable brake operating member and which defines a pressurizing chamber and a rear pressure chamber on respective front and rear sides thereof;

- a brake cylinder) connected to said pressurizing chamber;

- an assisting cylinder including a housing, and an assisting piston fluid-tightly and slidably fitted in said housing and



cooperating with said housing to define an assisting chamber and an assisting rear pressure chamber on respective front and rear sides thereof, said assisting chamber being connected to said brake cylinder and said master cylinder such that said assisting chamber is located between said brake cylinder and said master cylinder, said assisting cylinder being operated according to the pressure of the fluid in said assisting rear pressure chamber;

a master-cylinder cut-off valve disposed between said assisting chamber and said pressurizing chamber, and having an open state in which said assisting chamber and said pressurizing chambers are communicated with each other, and a closed state in which said assisting chamber and said pressurizing chamber are isolated from each other;

a braking characteristic control device operable to control at least one of a pressure of the fluid in said rear pressure chamber of said master cylinder and a pressure of the fluid in said assisting rear pressure chamber, for thereby controlling braking characteristics of the braking system; and

at least one of (a) a first diagnosing device operable while said master-cylinder cut-off valve is in said closed state, to diagnose a manual-pressure-generating system on the basis of a relationship between an operating state of said manually operable brake operating member and the pressure of the fluid in said pressurizing chamber of said master cylinder, and (b) a second diagnosing device operable while said master-cylinder cut-off valve is in said closed state, to diagnose a brake-cylinder activating system on the basis of a relationship between the

pressure of the fluid in said brake cylinder and an operating state of said assisting cylinder.

37. A braking system comprising:

a master cylinder including a pressurizing piston which is operatively connected to a manually operable brake operating member and which partially defines a pressurizing chamber;

a stroke simulator connected to said pressurizing chamber;

a simulator control valve operable to control an operating state of said stroke simulator; and

a stroke control device operable to control said simulator control valve on the basis of an operating state of said brake operating member.

38. A braking system comprising:

a master cylinder including a pressurizing piston which is operatively connected to a manually operable brake operating member and which defines a pressurizing chamber and a rear pressure chamber on respective front and rear sides thereof;

a brake cylinder connected to said pressurizing chamber;

an assisting cylinder including a housing, and an assisting piston fluid-tightly and slidably fitted in said housing and cooperating with said housing to define an assisting chamber in front of said assisting piston, said assisting chamber being connected to said brake cylinder and said master cylinder such that said assisting chamber is located between said brake cylinder and said master cylinder;

a master-cylinder cut-off valve disposed between said assisting chamber and said pressurizing chamber, and having an open state in which said assisting chamber and said pressurizing chambers are communicated with each other, and a closed state in which said assisting chamber and said pressurizing chamber are isolated from each other;

a braking characteristic control device operable to control at least one of a pressure of the fluid in said rear pressure chamber of said master cylinder and a pressure of the fluid in said assisting rear pressure chamber, for thereby controlling braking characteristics of the braking system; and

a cut-off valve control device operable when said braking characteristic control device is operated to control said at least one of the pressure of the fluid in said rear pressure chamber and the pressure of the fluid in said assisting rear pressure chamber while said master-cylinder cut-off valve is placed in said closed state, said cut-off valve control device switching said master-cylinder cut-off valve to said open state when an operating speed of said manually operable brake operating member is not lower than a predetermined threshold.

39. A braking system comprising;

a hydraulic braking apparatus including (a) a brake cylinder operable to generate a hydraulic braking torque for braking a wheel of a vehicle, (b) a master cylinder including a pressurizing piston which is operatively connected to a manually operable brake operating member and which partially defines a

pressurizing chamber, said pressurizing piston being advanced to pressurize a working fluid to a value corresponding to an operating force of said brake operating member, (c) an assisting cylinder including a housing, and an assisting piston fluid-tightly and slidably fitted in said housing and cooperating with said housing to partially define an assisting chamber in front of said assisting piston, said assisting chamber being connected to said brake cylinder and said master cylinder such that said assisting chamber is located between said brake cylinder and said master cylinder, and (d) a brake-cylinder cut-off valve disposed between said assisting chamber and said brake cylinder and having an open state in which said assisting chamber and said brake cylinder are communicated with each other, and a closed state in which said assisting chamber and said brake cylinder are isolated from each other;

a regenerative braking apparatus including an electric motor which is operatively connected to said wheel and which is operable to generate a regenerative braking torque for braking said wheel;

a braking-pressure control valve device operable to control the pressure of the fluid in said brake cylinder such that a sum of said regenerative braking torque and said hydraulic braking torque substantially coincides with a desired total braking torque determined on the basis of an operating state of said brake operating member; and

a stand-by control device operable when the regenerative braking torque that can be generated by said electric motor of

said regenerative braking apparatus is not smaller than the determined desired total braking torque, said stand-by control device placing said brake-cylinder cut-off valve in said closed state, and controlling the pressure of the fluid in said assisting chamber, on the basis of at least one of said determined desired total braking torque and said regenerative braking torque that is generated by said electric motor.

40. A braking system according to claim 39, wherein said stand-by control device includes:

a possibility-obtaining portion operable on the basis of at least one of said determined required total braking torque and said regenerative braking torque generated by said electric motor; and

a control portion operable to command said braking-pressure control valve device to control the pressure of the fluid in said assisting chamber, on the basis of said possibility obtained by said possibility-obtaining portion.

41. A braking system comprising:

a hydraulic braking apparatus including (a) a brake cylinder operable to generate a hydraulic braking torque for braking a wheel of a vehicle, (b) a master cylinder including a pressurizing piston which is operatively connected to a manually operable brake operating member and which partially defines a pressurizing chamber, said pressurizing piston being advanced to pressurize a working fluid to a value corresponding to an

operating force of said brake operating member, (c) an assisting cylinder including a housing, and an assisting piston fluid-tightly and slidably fitted in said housing and cooperating with said housing to partially define an assisting chamber in front of said assisting piston, said assisting chamber being connected to said brake cylinder and said master cylinder such that said assisting chamber is located between said brake cylinder and said master cylinder, and (d) a brake-cylinder cut-off valve disposed between said assisting chamber and said brake cylinder and having an open state in which said assisting chamber and said brake cylinder are communicated with each other, and a closed state in which said assisting chamber and said brake cylinder are isolated from each other;

a regenerative braking apparatus including an electric motor which is operatively connected to said wheel and which is operable to generate a regenerative braking torque for braking said wheel;

a braking-pressure control valve device operable to control the pressure of the fluid in said brake cylinder such that a sum of said regenerative braking torque and said hydraulic braking torque substantially coincides with a desired total braking torque determined on the basis of an operating state of said brake operating member; and

a stand-by control device operable when the regenerative braking torque that can be generated by said electric motor of said regenerative braking apparatus is not smaller than the determined desired total braking torque, said stand-by control

device placing said brake-cylinder cut-off valve in said closed state, and controlling the pressure of the fluid in said assisting chamber, on the basis of at least one of an operating state of said hydraulic braking apparatus and an operating state of said regenerative braking apparatus.